Art. XIII.—*Observations on the Geology of Mount Mary and the Lower Werribee Valley.*

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On Quarter-sheet No. 8 S.W. of the Geological Survey of Victoria, published in 1864, a prominent hill, shaped like a double horseshoe, attracts notice. This is Mount Mary, known also as Green Hill. It has an explanatory note by the late Mr. Daintree, who surveyed the area included in the sheet, which reads :—"Blocks of white and yellow argillaceous sandstone containing Miocene Tertiary fossils are imbedded in the scoriaceous lava of Mount Mary, proving the extension of the Miocene strata to this point under the lava of the plains, these being ejected blocks during the eruption."

This induced me to make a few visits to the place extending over a period of several years.

The geology of the district is interesting, and necessitates so much careful observation that sufficient information has not yet been collected to admit of any definite conclusions being formed regarding certain of the rocks occurring along the Werribee River. It is, therefore, with some diffidence that I submit these few observations, perhaps somewhat prematurely, but brought forward now as opportunities for further examination of the locality may not present themselves within a reasonable time.

On referring to the Quarter-sheet mentioned, it is seen that the whole of the area included therein, except a fringe of alluvium along the Werribee River, has been marked as of volcanic origin. These volcanic rocks comprise basalts, scoriae and tuffs, and are of considerable thickness, representing the products of several eruptions from Mounts Mary and Cotterill, and unnamed points of eruption on the east and west of Mount Mary.

The summit of Mount Mary, apparently the highest point in the locality, is somewhere about 500 feet above sea level. The mount is of more than geological interest as it is the north-

western termination of the base line from Werribee, upon which the geodetic survey of Victoria has been founded. It lies due west of Melbourne, at a distance of 24 miles in a direct line.

The shape of the mount is not quite as shown on the Quarter-sheet. Instead of the unbroken rim on the south it has a distinct sloping hollow there in addition to that shown on the north, indicating ruptures of the rim of the old crater through which the lava flowed away in both directions when the volcano was in its expiring stage. The volcanic rocks visible comprise vesicular and dense basalts of light to dark bluish-grey and drab-grey colours; reddish-brown and chocolate decomposing scoriae; and yellow and grey consolidated tuffs. Some of the scoriae weathers into brick red soil. In parts the basalt is very tough and vesicular, and contains a little hyalite; and again it is fine-grained and splinters into fragments. Some portions of the scoriae are exceedingly friable, and occasional blocks show embedded pieces and fragments of basalt. On the northern slope great numbers of masses and blocks of vesicular basalt, scoriae, and consolidated tuffs occur. Some of the latter contain pieces of originally fossiliferous clays now turned into dense rock like porcelain-jasper, and other pieces altered only to a moderate extent. An interesting feature, shown by a few small pieces found at one place, is the intimate mixture of small fragments of scoriae with the altered clays showing casts of fossils. Owing to the absence of any natural or artificial sections here the nature of the rocks forming the mass of the mount can be determined only so far as the broken blocks will admit.

The fossiliferous blocks referred to occur near the summit on the north-western and western slopes of the mount. No blocks were noticed near the foot of the slopes, the lowest found being about 175 feet below the summit on the southern side. They consist of altered clays and fine sandy and gritty clays of brown, red, grey, yellow, and white colours. There is an entire absence of carbonate of lime from the fossiliferous pieces obtained, while in one or two cases a little silica was noticed, forming a coating on the casts of fossils. In the more altered pieces the fossils have been completely destroyed so far as determination is concerned, and consist merely of badly defined

lines and blotches, indicating, apparently, the worm-like appearance of scaphopods, and the coarser stems of bryozoa. Among the less altered pieces, however, the casts of many of the fossils are still sufficiently well-preserved to admit of generic determination, and in a few cases specifically also. Doubtless, long and careful searching would disclose quite a number of determinable species.

The following list represents those sufficiently distinct to mention :—

Pteropoda.

Vaginella eligmostoma, Tate

Gastropoda.

Bathytoma angustifrons, Tate
Clathurella sp.
Cancellaria sp.
Marginella sp.
Siphonalia sp.
Murex sp.
Turritella sp.
Natica sp.

Lamellibranchiata.

Placunanomia? sp.
Spondylus pseudoradula, McCoy
Lima? sp.
Pecten sturtianus, Tate, prob.
Amussium zitteli, Hutton
Septifer? sp.
Glycimeris laticostatus, Quoy and Gaimard
Leda huttoni, T. Woods.
Trigonia subundulata, Jenkins
Cardita sp.
Corbula ephamilla, Tate?

Actinozoa.

[1] Sphenotrochus alatus, T. Woods

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[1] This Coral, of which two examples were obtained, has been kindly identified by Mr. J. Dennant, F.G.S., F.C.S., to whom I am also indebted for determining several other fossils in the list.

Brachiopoda.

Magellania sp.

Bryozoa.—Several species.

Foraminifera.—Several species.

The preceding list appears to indicate an Eocene age for the fossils, and they are herein provisionally referred to that age. This agrees with the note on the Quarter-sheet referring to them as Miocene fossils, the Miocene of the old survey being, as is now generally acknowledged by palaeontologists, either Eocene or Oligocene. There seems no reason to doubt that the beds from which these fossiliferous blocks were torn form portion of those beds of Eocene age occurring at Newport and Altona, near the western shore of Port Phillip.[1] These deposits have been proved by bores and shafts to there underlie the volcanic rocks of the Werribee plains.

On the summit of the mount, a small shallow excavation shows the occurrence of whitish clay, probably a large ejected block. This clay has evidently been used as a pigment by aboriginals as the excavation shows no evidence of being a natural one, and small pieces and flakes of the clays are found in the immediate vicinity. Along the summit also, and almost exclusively at the western end, flakes and "cores" of various rocks—both local and foreign to the locality—are fairly plentiful. The local ones comprise the ejected clays from those only slightly altered to those which are practically porcelain-jaspers. The absence at the surface of greater numbers of blocks of this rock is probably due to the fact that the aboriginals have used for their implements and other purposes nearly all the material observable on the mount. The foreign flakes are of red and white quartz, quartzites, hornstones, and the indurated sandstones which are found among the pebbly gravels of the Werribee Valley. Several hammers and axes in the rough, together with a ground

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1 "A Contribution to our Knowledge of the Tertiaries in the Neighborhood of Melbourne." T. S. Hall, M.A., and G. B. Pritchard. Proc. Roy. Soc. Vic., vol. ix., n.s. 1896.

"Report of the Secretary for Mines Victoria, for year 1894."

"Report on boring for Coal at Newport." Jas. Stirling. Prog. Rep. Geol. Sur. Vic., No. ix.

"Report on the Brown Coals and Lignites of Victoria." Jas. Stirling. Prog. Rep. Geol. Sur. Vic., No. x., pp. 80-2.

one, were found here, and numbers of pebbles of quartz, either intact, or more or less flaked. Few flakes were noticed away from the summit, or high up along the sides, thus indicating that the aboriginals used the mount as a look-out and rendezvous. It gives a most extensive view across the country in every direction, especially over the treeless Werribee Plains, and towards the Brisbane Ranges and the You Yangs.

The only trees on the mount are a few sheoaks, and an occasional lightwood, though a few eucalypts grow in the vales below, and fine specimens of them may be seen along the Werribee River, where, also, there are several other kinds of trees, conspicuous among them being the native laurel.

On examination of the natural sections, and the road cuttings at the bridge over the Werribee, one and a half miles east of Mount Mary, it is seen that at least two flows of basalt are present, separated by thin beds of tuff and lapilli; while along the river, near the sharp bend in the N.E. corner of Allot. 25B, parish of Werribee, as shown in the Quarter-sheet, a fine natural section is visible in the cliffs. The following note thereon describing this section, is as follows :—"28 feet hard scoriaceous basalt, laminated and jointed; 24 feet soft friable basalt, with hard imbedded nodules; 9 feet volcanic ash; 13 feet thin laminae of soft decomposing scoriaceous basalt; 30 feet soft friable basalt, enclosing nodules and irregular bands of augitic basalt."

These tuffs consist of a firmly cemented fragmentary rock, comprising a mass of subangular and rounded grains of sand, and fragments of basalt, scoriae, and tachylite, up to the size of grains of sand through which are distributed larger pieces of scoriae and vesicular basalt. The scoriae fragments are mostly decomposed into yellow clay.

Interbedded with these are thin bands of very fine material—volcanic dust—which forms a coherent rock, while along bedding and joint planes and exposed places, a thin crust of carbonate of lime has been deposited. This gives the rock a pretty, white appearance, noticeable from a long distance. The coherent nature of these tuffs seems to indicate that they were mixed with a considerable quantity of water prior to deposition and were not accumulations of dry material.

The sections shown by the aforementioned road cuttings are of interest, especially that on the eastern side of the river. Taking that one—which is some 420 feet long—in detail, we find the following succession, commencing at the eastern end :—

A.—Red and greyish-red soil with small pieces of decomposing basalt, and masses of greyish-white carbonates of lime and magnesia. This has a basin-shaped appearance, taking the section between the surface and the slope of the road, and in the middle is about 5 feet thick, gradually tapering off to the surface as traced west, and overlying B. Its length is about 60 feet.

B.—Dense and partly vesicular dark bluish basalt, full of blebs and patches of carbonate of lime. The rock is considerably jointed, changing, in the lower part, into laminated and nodular basalt. The material in the interstices and portions between the nodules is quite decomposed. This basalt is about 14 feet thick in the thickest part, and extends for about 150 feet along the cutting, terminating steeply near its western end, thus overlying C for nearly the whole way.

C.—Very vesicular basalt, weathering in a ragged semi-columnar manner, and greatly jointed, quite different in general appearance from the laminated structure of the immediately overlying basalt. It shows a length of about 210 feet, sloping off very gradually on the east, but more steeply on the west. It is about 6 feet thick in the middle.

The basalt in this section seems to have been derived from Mount Mary, and consists of at least two flows. The old surface of C appears to have been a very irregular one, probably due to unequal cooling of the surface of the flow, and the jutting prominences of ragged blocks torn from the parent mass.

In one or two places there are pieces of C wedged *in situ* into the lower portion of B. At the western end of the cutting the lower portion of B consists of a band of dense dark blue basalt, the upper portion of decomposing nodular and laminated basalt.

The western end of C shows the ropy structure of strained viscous lava, and at one place on the south side of the cutting a pear-shaped piece may be seen.

In the lowest visible portion the rock is a decomposing finely nodular and laminated basalt—the laminations simulating current bedding in their diverse dips. This, also, is perhaps due to strain before solidification.

On the northern side in this lowest portion is an included block of altered mudstone or clay, about 5 feet above the road level. It appears to have been torn from its original bed and carried along by the lava flow, or, on the other hand it may be an ejected block similar to those on Mount Mary. I think, however, that the former is the more probable, as the general appearance of the vicinity does not convey the impression that an old crater had existed there.

Near this included mass there is a nearly vertical thin band of hard vesicular basalt, which may be a small dyke, or a harder portion of the main flow, as, though there is a sharp break in the western side between it and the containing decomposing nodular basalt, it seems to merge gradually into the decomposed rock on the eastern side.

Section on Road on Western Bank of Werribee River.

This section runs north and south, parallel with the stream. It is only about 100 feet long. The lowest portion consists of nodular, decomposed, massively-jointed basalt, with patches of hard, vesicular basalt at the northern end, and nodules of harder basalt at the southern end. At this end it is about 28 to 30 feet thick, thinning considerably towards the north.

Immediately overlying is a bed varying from 2 feet 6 inches to 3 feet 6 inches of friable tuff and lapilli, having an uneven appearance, as if sprinkled in a dry state over a surface showing considerable inequalities, due to irregular cooling and solidification of the flow. The lapilli bed contains a great quantity of medium-sized grains of quartz, as if portions of a coarse, sandy, or gritty bed had been torn from the walls of the crater, absorbed by the volcano, and later on spread over the adjacent country, mixed with fragments of scoria and volcanic mud.

The tuff and lapilli bed has a considerable amount of carbonate of lime occurring as a coating along the bedding and joint planes. Harder and firmer vesicular basalt, very laminated in places, and considerably decomposed, rests on this bed. It runs to the surface, and varies in thickness from some 20 feet at the southern to 30 feet at the northern end.

The general appearance of these sections when viewed from the north up the Werribee gives one the impression that the flows originated at Mount Mary, as they appear to be at a slightly lower level on the eastern than on the western side of the river.

The nearest point of eruption of any size—other than Mount Mary—to this place is a hill shown in Allot. 23c, parish of Tarneit, on Quarter-sheet 8 S.E., and described thereon as a "Volcanic hill—red scoriaceous basalt." This hill rises to a height of less than 100 feet above the plain, and the summit on the northern, eastern, and southern sides shows a rising succession of fairly well-defined rims, one inside the other, of scoriaceous and partially laminated dense basalt of light and dark grey colour. On the north-western and western sides the slope is gradual and regular on to the hollow part of the adjoining plain, as if the final flow from the point had run off in this direction, while simply welling up and solidifying in that position on the northern and eastern sides. On the southern and south-western sides the slope is gradual, but along a low rise. There are present numerous aboriginal stone flakes and occasional implements and pebbles of the same kinds of rocks as on Mount Mary, with the exception of the altered clays. Of these one small piece only, of what has somewhat the appearance of this clay, was found. The absence of this rock seems to prove either the absence of these clays underlying at a depth, as in the case of Mount Mary, or that the volcanic forces here were not strong enough to break away the walls of the crater and eject such broken blocks, or even to distribute tuffs in the vicinity; thus being no more than sufficient to cause the molten rock to quietly well forth and flow away, and this even only on the north-western side.

Taking the country generally, we find that volcanic products represented by basalt, scoria, tuff and lapilli cover nearly the

whole of the district, overlain in the depressions and along the Werribee and tributary creeks by alluvium, and towards the north by pebbly drift—to be mentioned later—and a covering of varying thickness of clays of obscure origin.

The Werribee has cut for itself a deep gorge through these volcanic rocks, and though not examined the whole way from Mount Mary Bridge to that at Exford, still, wherever inspected at various points along the valley, no other deposits than those and recent drift and alluvium were noticed. The river cliffs in some places exceed 130 feet in height, and for a long way up stream from the Mount Mary Bridge beds similar in appearance and position to the tuff beds occur on the eastern side of the river, and doubtless on the western side also.

Now, turning to that portion of the Werribee Valley near Exford, the following geological features may be seen :—In the upper portion of the first gully on the western side of the river below the bridge on the Melbourne-Ballarat Road, we find a thick capping of drift, consisting of pebbles from the size of a man's head to that of a pea, mixed with gravel, sand, and large pebbles of vesicular basalt, resting on the basaltic sheet of the plains. These pebbles have probably been derived from Ordovician rocks, and comprise quartz, quartzites, indurated sandstones, etc.

As the gully is followed down towards its junction with the river, this pebbly drift is seen to occur on both slopes, and shows in small section directly overlying the vesicular basalt. It has here a thickness of something like 50 feet.

Underlying the vesicular basalt directly is a deposit of fine, sandy mudstone, of light grey and fawn colours, with a few pebbles like those seen at the Werribee Bridge at Exford—to be mentioned later. This is underlain by a sharply defined bed, 3 feet thick as far as visible, of medium-sized pebbly gravels of indurated sandstones, quartz, and quartzites. These, again, lie on dense, dark, laminated, and irregularly-jointed basalt.

The succession of rocks in descending order is thus :—

A.—Coarse pebbly drift lying on the eroded flank and surface of B.

B.—Vesicular scoriaceous basalt of the Werribee Plains containing pieces of tachylite.

C.—5 feet of mudstone, with few pebbles, underlain sharply by 3 feet of pebbly gravels. (These gravels are probably thicker, but the section precludes more from being seen).

D.—Dense, dark, laminated, and irregularly-jointed basalt, with small crystals of a glassy felspar?, showing in bed of gully where alluvium masks the surface.

I was not enabled to examine the river cliffs near here, so cannot say anything more with respect to the succession of rocks.

At the Werribee Bridge at Exford, again, in the road cutting on the western bank, the following succession is noticeable, beginning at the highest :—

A.—A few inches to 6 feet of drift consisting of pebbles of rocks similar to those referred to in the gully section.

B.—Vesicular and scoriaceous basalt, in part decomposing in laminations. Layers of white carbonate of lime occur in this basalt; also a considerable amount of white clay, containing decomposing amygdules of a brownish colour and soapy nature.

C.—Very finely sandy clays of white, brownish-yellow and reddish colours, containing fine subangular grains of quartz, and numerous small pebbles of quartz, and dense slightly vesicular basalt in the higher portion; but full of such pebbles in the lower portion.

From this point to the river level—about 30 feet below—the rock is masked by material washed down the slope, but almost without doubt basalt occurs beneath, as at the junction of Toolern Creek with the Werribee River, about 200 yards below the bridge, basalt can be seen down to the water level in the eastern cliffs.

This sandy clay has rather a peculiar appearance, and may not entirely owe its present location to transportation by water. It may perhaps be a mixture of water-transported material, and that directly derived from a volcanic source.

In the explanatory sheet of notes published with Quarter-sheet No. 12 N.E. (Bacchus Marsh), Messrs. R. Daintree and C. S. Wilkinson, who surveyed the area included therein, make the following notes :—Note 15, "Section at head of small ravine, showing 30 feet vesicular basalt, and 4 feet volcanic ash, mixed with a little white quartz sand resting on red ferruginous sand

with fine quartz pebble drift." Note 19, "A thin layer of rounded quartz pebble drift occurs here between the Miocene Tertiary and Upper Volcanic. It is probably the continuation southwards of the Older Pliocene auriferous drift underlying the basaltic tableland about six miles north of Bacchus Marsh. . . ."

These notes refer to deposits occurring in the cliffs along the Parwan Creek, some seven miles to the north-west of Exford, and they apply to a certain extent to the sections at and near Exford.

The former note quoted indicates a combined volcanic and ordinary sedimentary origin for these Parwan Creek beds as may be the case regarding the finer beds near Exford. In some places here this bed of fine material appears to have been altered by the covering basalt, being slightly hardened and of a reddish-pink colour. To test the probability of this I took a piece of the greenish-yellow rock and first roasted, then burnt it. The result was a rock very similar in hardness, colour and general appearance to that in question, which points towards its alteration by heated contact.

The surface pebbly drift may also be seen at the following places:—On the top of the flat ridge between the Toolern Creek and the Werribee River; on the top of, and stretching back from, the cliffs on the east and west of the Werribee for some distance south of the Melbourne Road; at the junction of the Bacchus Marsh and Ballan Roads in the south-west corner of Allotment 18B, parish of Mooradoranook. It probably extends along from here to the Werribee Bridge at Exford, but this portion was not examined.

It can also be seen along the railway between Melton and Bacchus Marsh, covering large areas on the north of the railway, as shown in Quarter-sheet 12 N.E. This is probably the main mass of which the portions herein specially described are the attenuated southern remnants.

We find, therefore, that the locality near the Exford Bridge shows that there are at least two flows of basalt, with an intercalated bed of pebbly drift, overlain by a thin bed of very fine gritty mudstone or clay; while overlying the upper of these two flows of basalt is a bed of varying thickness of coarse to fine pebbly drift.

This surface drift appears too extensive to be attributed to fluviatile action alone, and I am inclined to regard it as of combined fluviatile and littoral origin, especially as it shows evidence of having been subjected to a great deal of attrition, whereby all the softer rocks, such as argillaceous slates and shales, have been worn completely away, and only the harder siliceous rocks left. This refers of course to that portion of the drift which comprises sedimentary rocks foreign to the locality, thus excluding local basalts.

It would, therefore, appear as if the surface drift had been laid down along the shore of a shallow sea, the bed of which consisted of hard basalt while this basalt itself had flowed over a thin bed of coarse and fine sediments, which also had been deposited along a shore line, but in deeper water.

This suggests the probability that a shallow sea existed in the locality at a former period, in which Mounts Mary and Cotterill, as well perhaps as some other high points, stood as islands in a state of fairly energetic eruption; that their lava flows, running in a northerly and westerly direction respectively, were poured over a sea-floor, and thus were submarine flows which gradually shallowed the sea; that during cessations in eruptions or deviations in flows from these stated directions, the deposits of siliceous pebbles were brought down by a large river from the Ordovician highlands above Bacchus Marsh; that the finer sediment on the upper portions of this intercalated bed, which consists of an intimate mixture of rounded and sub-angular fine quartz grains embedded in a rather harsh, greenish-yellow clay, is possibly partly of sedimentary and partly of volcanic origin; that another lava flow spread itself over this one, advancing probably nearer to the shore line than the former one; that cessation or deviation again took place long enough for a thicker deposit of pebbly gravels to be formed; that during the whole of this time the coast line was gradually rising, and now came above the surface while the volcanic forces were gradually becoming extinct; that as the land continued to rise and the sea to recede the latter carried away the outer margin of the littoral deposits, and continued to do so at the same relative rate as the land was rising, thus precluding the probability of any patches of it being left on the normal level of the underlying basalt.

There appears to be conclusive evidence that the land around Port Phillip has risen considerably since late Tertiary times, and assuming this to be so, and, also, that the tentative theory just advanced is the correct one, the age of this pebbly drift is probably late Pliocene or Pleistocene.